

University of Groningen

## Pharmaceutical care by clinical pharmacists in patients with musculoskeletal disease

Duyvendak, Michiel

**IMPORTANT NOTE:** You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

*Document Version*

Publisher's PDF, also known as Version of record

*Publication date:*  
2010

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Duyvendak, M. (2010). *Pharmaceutical care by clinical pharmacists in patients with musculoskeletal disease*. s.n.

### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

# Chapter 6

## Peri-Operative Drug Management

**Clinical pharmacy services reduce potential drug related problems in orthopedic patients**

Michiel Duyvendak<sup>1,2</sup> | Eric N. Van Roon<sup>1,3</sup> | Mark Nauntun<sup>4</sup>  
Judith Bosman<sup>5</sup> | Joanna Klopowska<sup>6</sup> | Jacobus R.B.J. Brouwers<sup>1,7</sup>

1. Department of Pharmacotherapy and Pharmaceutical Care, University of Groningen, Groningen, The Netherlands
2. Department of Clinical Pharmacy, Antonius Hospital Sneek, Sneek, The Netherlands
3. Department of Clinical Pharmacology, Medical Centre Leeuwarden, Leeuwarden, The Netherlands
4. School of Environmental and Life Science, Charles Darwin University, Northern Territory, Australia
5. Department of Clinical Pharmacy, Isala Clinics, Zwolle, The Netherlands
6. Department of Clinical Pharmacy, Amsterdam Medical Centre, Amsterdam, The Netherlands
7. Expertise Centre for Pharmacotherapy in Older Persons (Ephor),  
University Medical Center Utrecht, Utrecht, The Netherlands

**Submitted**



## **Abstract**

### *Introduction*

Drug management in the peri-operative period is a complex process. Only limited information is available in the literature on the effects of clinical pharmaceutical care in peri-operative drug management. Aim of this study was to determine the effect of clinical pharmacy-based interventions on the number of potential and actual drug-related problems (DRPs) in patients undergoing elective orthopedic surgery.

### *Methods*

A prospective, non-randomized, controlled, observational intervention study of patients undergoing elective hip- or knee replacement surgery was carried out. Patients in the control group received care as usual, including preoperative screening by a nurse practitioner, anaesthesiologist and general physician. Electronic medication surveillance was carried out for all patients. Following a pre-operative drug use interview by the pharmacy the intervention group received a medication review and advice was given to the anesthesiologist.

For each group the average number of DRPs per patient was determined.

### *Results*

The number of potential and actual DRPs was reduced by 58% from an average of 3.6 to 1.5 per patient in the control- and intervention group, respectively. Forty seven percent of the medication used at admission showed discrepancies with data from other sources (community pharmacist, general practitioner). At discharge it was revealed that in 32% of patients at least one drug could be stopped and in 17% of patients a necessary drug was omitted.

### *Conclusion*

The addition of a clinical pharmacy service to the preadmission clinic enhances medication safety in patients undergoing elective orthopedic surgery. Clinical pharmacy services should be part of patient care for orthopedic surgery patients.

## Introduction

Medical safety continues to receive widespread public attention often fueled by tragic events in hospital which were highly publicized in the public domain<sup>1</sup>.

In the Netherlands an estimated 19,000 hospital admissions and 1250 deaths occur annually as a result of preventable medication errors<sup>2</sup>. Evidence from the last twenty years suggests that the addition of clinical pharmacist services in the care of inpatients generally resulted in improved care, with no evidence of harm<sup>3</sup>, and reduction of medication errors, mortality, drug costs and length of hospital stay<sup>4-6</sup>.

The use of medicines in patients undergoing elective orthopedic hip- or knee surgery is complex because of a large variety of medicines used at admission and given during hospitalization. The clinical pharmacist can play a role in the peri-operative drug management, because of the familiarity with drug names, administration routes, drug formulations, drug interactions, non-prescription drugs (over-the-counter (OTC)) and herbal medicine<sup>7-9</sup>.

Up to 64% of all hospital prescribing errors can be attributed to incomplete medication histories at the time of admission<sup>10;11</sup>. Studies show that 50-81% of all patients have at least 1 medication discrepancy at admission and/or discharge between the different sources (the patient, the community pharmacist's data, or physician's data)<sup>12-18</sup>. Duthie *et al.* reported that 29% of patients receiving cardiovascular medications inadvertently stopped at least one of these drugs due to incomplete medication histories<sup>19</sup>. A study involving surgical patients revealed that the preoperative medication histories from the surgery and anesthesiology departments showed at least one discrepancy in 73% of patients<sup>20</sup>.

The aim of medication reconciliation is to obtain the best possible medication history. The medication reconciliation process involves three steps<sup>21</sup>:

- I. Verification (collection of the medication history)
- II. Clarification (ensuring that the medications and doses are appropriate)
- III. Reconciliation (documentation of changes in the orders compared to history)

Patient contact is essential for determining the accurate medication use of the patient, but also for optimizing pharmaceutical patient care<sup>22-24</sup>. Studies have shown that pharmacists often obtain more information than physicians and nurses about patients' medication use when they are admitted to hospital<sup>9;25;26</sup>. Medication reconciliation performed by pharmacists together with physicians and nurses using an electronic application results in a reduction of potential drug-related problems<sup>27</sup>.

Moreover, a study showed that even within the hospital medication discrepancies occur between surgery and anesthesiology histories in 73% of patients<sup>20</sup>. A recent study showed that pharmacy technicians at the pre-operative clinic could significantly decrease medication discrepancies<sup>28</sup>. Moreover, it was shown that the involvement of the pharmacy technician resulted in a non-significant decrease of peri-operative anticoagulation errors. However, the study only concerned pre-operative drug management and did not report on the impact of a pharmacy service for the entire duration of

the patients' hospitalization. The only study considering peri-operative drug management showed pharmacy involvement in the preoperative admission clinic resulted in 76 interventions in 50 patients. However no specific details were given on the type of peri-operative advice given<sup>22</sup>.

Since only little is known about the value of complete peri-operative drug management, including medication reconciliation, comprehensive medication review, and discharge service, by the clinical pharmacist, we performed a study assessing these aspects.

### *Objective*

The aim of our study was to determine the effect of a clinical pharmacist-based service on the number of potential and actual drug-related problems (DRPs) in patients undergoing elective orthopedic hip- or knee surgery.

## **Methods**

### *Population*

This was a prospective, non-randomized, controlled, observational intervention study of patients who underwent elective hip- or knee replacement surgery in a general hospital in the northern part of The Netherlands. The population was divided into an historic control group and a subsequent intervention group.

### *Exclusion criteria*

Patients were excluded from this study if their hospital stay was less than 5 days, if they underwent revision surgery for previous knee- or hip surgery, or if they underwent surgery for hip fractures.

### *Drug Related Problems*

A DRP is defined as an event or circumstance concerning the pharmacological therapy of a patient that interferes effectively or possibly with gaining an optimum outcome<sup>29</sup>. We classified DRPs using the MAI system<sup>30,31</sup>. All potential or actual DRPs were determined by the primary author (MD) during the patient's hospitalization in both groups. All potential DRPs were later reviewed by another pharmacist (EvR, MN) who was not involved in the medication review. Consensus occurred in case of initial disagreement. To detect a case of "wrong drug" the updated Beers criteria<sup>32</sup> were used (e.g. indomethacin or amitriptylin). A drug-drug interaction was considered relevant according to the appraisal model developed by van Roon *et al.*<sup>33</sup>. This model provides criteria to select drug-drug interactions that require action to be undertaken by the pharmacist.

### *Historic Control Group*

The prospective control group received usual pharmaceutical care throughout their hospitalization. This comprised primarily of remote electronic surveillance of medication with the pharmacist screening for drug-drug interactions, medication duplication and assessment of dose. During the preoperative screening in the study hospital all patients were assessed by a preadmission nurse and thereafter an anesthesiologist and an internal medicine specialist. The patient self-reported their medication use to a nurse before admission. It was not standard procedure to contact the patient's general practitioner (GP) or community pharmacy to obtain their current intended medication profile. There was no structured intake interview concerning medication use when patients were admitted to the hospital.

### *Intervention Group*

The intervention period immediately followed the control period. The intervention group received usual pharmaceutical care, but was additionally offered a comprehensive medication review, which included an interview with the patient by a pharmacist. The patient's general practitioner and community pharmacy were also contacted to obtain information regarding the patient's medication use. A best possible medication profile was produced and assessed for DRPs.

During the preoperative screening, generally one to six weeks before hospitalization, the pharmacist assessed the patient for any DRPs using a checklist, which was developed prior to the intervention. This checklist comprised of a number of medications which are recommended to be stopped before surgery (e.g., low dose aspirin, sulphonylurea antidiabetic agents) in most patients. Furthermore, common DRPs were listed, based upon evidence from the international literature. Consensus was reached between all study investigators. Following the development of this checklist by the pharmacy department, it was reviewed by the medical specialist members from the department of anesthesiology, internal medicine, and orthopedic surgery. The pharmacist provided advice to the anesthesiologist and/or general practitioner in order to prevent peri-operative DRPs. A written feedback method was used for intervention proposals to the doctors.

A structured report of the patient intake interview detected actual drug use at admission. During the post-operative period of each patient, the pharmacist reviewed the patient's medication and, if required, proposed interventions to the responsible orthopedic surgeon.

### *Acceptance of intervention proposals*

In order to determine the acceptance rate of the intervention proposals the anesthesiologist provided written feedback on the preoperative medication chart on which the intervention recommendations had been supplied. These charts were sent to the pharmacy before the patient was admitted to hospital for their surgery. In the case of physician non-response, reminders by telephone followed until the chart was received. General practitioners received case record forms with the intervention proposals on which feedback could be written. In case of non-response one written reminder was sent and finally one reminder by telephone was given.

### *Patient characteristics*

The following demographic data of the patient were collected or calculated: age, body mass index (BMI), estimated creatinine clearance by means of the Cockcroft & Gault equation<sup>34</sup>, ASA-score<sup>35</sup>, Charlson comorbidity index<sup>36</sup>, number of medications (different ATC-codes<sup>37</sup>) used in the ambulant setting determined on admission of patient to the hospital, number of medications received in the hospital (excl. medication already in use at admittance to hospital), and type of surgery.

### *Endpoints*

The primary endpoint of this study was:

- Number of actual and potential DRPs.

The secondary endpoints of this study were:

- Number of (accepted) interventions in the hospital.
- Number of (accepted) interventions by the patients' general practitioner.
- Degree of incongruence of medication use data using patient information compared to information from general practitioner or community pharmacist.
- Medication appropriateness index (MAI)-score.

### *Statistics*

Data were analysed using SPSS® version 15 (SPSS, Chicago, IL, United States). Percentages were calculated using the total of the number of different drugs used per patient in each group. For continuous variables average and standard deviation were calculated and for categorical variables results were expressed as percentage. Differences between the controls and intervention group were determined with Chi-squared test, Fisher exact test or Mann-Whitney U test, depending on the data type. The normality of the distribution of the data was tested by means of a Kolmogorov-Smirnov test. A p-value <0.05 was considered significant.

### *Ethical aspects*

The research was approved by the Hospital Medical Ethical Review Board. All patients provided informed consent to participate.

## **Results**

In both the control and intervention group 194 and 95 patients were included, respectively. The patient characteristics are displayed in Table 1. The only statistically significant differences between the two groups were that patients in the historical control group used fewer medications in the ambulant setting as well as in hospital.



**Table 1: Patient characteristics.**

	Control (n=194) (SD)	Intervention (n=95) (SD)	Statistics (p-value)
Age (years)	72 ( $\pm 8$ )	71 ( $\pm 11$ )	NS
Sex (% female)	72%	65%	NS
BMI (kg/m <sup>2</sup> )	28.0 ( $\pm 4.7$ )	28.8 ( $\pm 4.4$ )	NS
ASA-score	2.4 ( $\pm 0.7$ )	2.3 ( $\pm 0.6$ )	NS
Charlson index	0.73 ( $\pm 1.11$ )	0.77 ( $\pm 1.18$ )	NS
eCreatinine Clearance (Cockcroft-Gault) (ml/min)	74 ( $\pm 23$ )	78 ( $\pm 28$ )	NS
% Total hip replacement	60.3	53.7	NS
Number of medicines used in ambulant setting	3.5 ( $\pm 2.6$ )	4.7 ( $\pm 3.0$ )	<0.001
Number of medicines used during hospital stay*	11.4 ( $\pm 2.4$ )	12.0 ( $\pm 2.4$ )	<0.01

**Abbreviations:** BMI: Body mass index, ASA: American society of anesthesiologists.

\*excluding medication used upon admission.

**Table 2: Actual and potential drug related problems during hospital stay (% of total number of drugs used in population)**

	Control (n=2831)	Intervention (n=1654)	Statistics (p-value)
Total number of problems (%)	700 (24.7%)	147 (8.9%)	<0.001
Mean number of problems per patient (SD)	3.6 ( $\pm 2.6$ )	1.5 ( $\pm 1.6$ )	<0.001
Mean MAI-score (SD)	3.7 ( $\pm 2.7$ )	1.5 ( $\pm 2.0$ )	<0.001
Mean length of hospital stay (days) (SD)	8.8 ( $\pm 3.5$ )	8.2 ( $\pm 3.1$ )	<0.05
Incorrect drug selection (Beers-criteria)	167 (5.9%)	14 (0.8%)	<0.001
Drug not withheld prior to surgery	158 (5.6%)	11 (0.7%)	<0.001
Drug interaction	121 (4.3%)	75 (4.5%)	NS
Duplication	102 (3.6%)	9 (0.5%)	<0.001
Wrong dose	58 (2.0%)	12 (0.7%)	<0.01
Condition not adequately treated	51 (1.8%)	13 (0.8%)	<0.01
Toxicity or adverse drug event evident	16 (0.6%)	2 (0.1%)	<0.05
Drug duration inappropriate	13 (0.5%)	4 (0.2%)	NS
Lack of laboratory monitoring	8 (0.3%)	3 (0.2%)	NS
Other problems	6 (0.2%)	4 (0.2%)	NS

**Abbreviations:** SD: standard deviation, MAI: Medication appropriateness index

**Table 3: Overview of types of interventions**

Intervention proposal to prescriber	Specialist		General Practitioner	
	Number (%)	% approved	Number (%)	% approved
Cessation of medication to prevent duplication	112 (36.2)	97.3		
Peri-operative cessation of RAAS-inhibitors/diuretics	55 (17.8)	92.7		
Permanent cessation of drug without indication	54 (17.5)	100.0	11 (27.5)	63.6
Restart of drug at discharge	18 (5.8)	100.0	3 (7.5)	100.0
Peri-operative cessation platelet inhibitors	18 (5.8)	100.0		
Peri-operative cessation of oral antidiabetics	14 (4.5)	93.3		
Peri-operative cessation of bisphosphonates	8 (2.6)	100.0		
Start of drug because of undertreatment	7 (2.3)	100.0	9 (22.5)	44.4
Peri-operative cessation of coumarines	6 (1.9)	100.0		
Dose reduction	6 (1.9)	100.0	5 (12.5)	60.0
Prevention of NSAID gastropathy with PPI	4 (1.3)	100.0	2 (5.0)	50.0
Laboratory monitoring	3 (1.0)	100.0		
Screening for osteoporosis			3 (7.5)	33.3
Dose increase	2 (0.6)	100.0	2 (5.0)	100.0
Substitute short-acting BZ for long-acting BZ	2 (0.6)	100.0	4 (10.0)	75.0
Peri-operative cessation of female hormones			1 (2.5)	100.0
Total	309	97.4	40	62.5

**Abbreviations:** RAAS: Renin-angiotensin-aldosterone-system, NSAID: Non-steroidal anti-inflammatory drug, PPI: Protonpump-inhibitor, SSRI: Selective serotonin reuptake-inhibitor; BZ = benzodiazepine.

**Table 4: Discrepancies of drugs used in the ambulant setting comparing patient information with outpatient information sources (% of total number of drugs at admittance)**

Type of discrepancy	Community pharmacy	General practitioner
	n=388	n=388
Total number of drug discrepancies (%)	179 (46)	187(48)
Drug not on list (%)	64 (15)	72 (19)
• Prescription drug	28	33
• Over the counter drug	27	30
• Dietary supplement	2	2
• Homeopathy	1	1
• Vitamins/minerals	2	4
• Phytotherapy	4	2
Drug commenced after preoperative screening (%)	58 (15)	58 (15)
Higher dose than reported by patient (%)	40 (10)	41 (11)
Patient ceased drug (%)	10 (3)	7 (2)
Lower dose than reported by patient (%)	7 (2)	9 (2)

Table 2 provides an overview of the DRPs that were identified in the control and intervention groups. The following DRPs occurred significantly less frequently in the intervention group: wrong drug, drug duplication, drug not withheld before the operation. Moreover, a significant reduction in adverse events (e.g. electrolyte disturbances caused by diuretics and supratherapeutic INR's caused by coumarines) was determined. The percentage of patients with a 'wrong drug' decreased from 69% in the control group to 8% in the intervention group. The interventions proposed and/or carried out during the intervention phase are shown in Table 3. The most frequent intervention was cessation of medication used in the ambulant setting to prevent duplication with drugs prescribed peri-operatively per protocol by the surgeon. Furthermore, peri-operative cessation of renin-angiotensin-aldosteron-system(RAAS)-inhibitors and/or diuretics was a frequently performed intervention. In 24% of patients (8% of all interventions) interventions had to be carried out before the admission of the patient (e.g. cessation of anticoagulants, platelet inhibitors and selective serotonin reuptake-inhibitors (SSRI's)) and another 25% of interventions concerned cessation of drugs on the day of the operation (oral antidiabetics, RAAS-inhibitors or diuretics and bisphosphonates). The feedback from general practitioners shows a lower acceptance rate (63%) compared to specialists (97%). Finally, in 32% of patients (54 separate occasions) a drug was stopped by the clinical pharmacist because there was no longer an indication for its use and in 17% of the patients (18 separate occasions) the clinical pharmacist recommended a medication was to be recommenced at discharge. The majority (97%) of the interventions were approved by the anesthesiologist and/or orthopedic surgeon.

Table 4 shows that 47% of the medication information obtained by the hospital pharmacy from the patient's community pharmacy and general practitioner had discrepancies after the clinical pharmacist retrieved information from the patient. The most frequently encountered discrepancy was that a patient admitted to using a medication (prescribed and OTC) which was not provided by the community pharmacy (15% of discrepancies) and/or general practitioner (19% of discrepancies). Furthermore, 15% of prescriptions were started after the preoperative pharmacist consultation.

## **Discussion**

### *Main findings*

This study shows that clinical pharmacy services can have a significant impact on patient safety. The average number of actual and potential DRPs in the control group was 3.6 per patient, despite routine electronic medication surveillance, preoperative screening by an anesthesiologist and internal medicine specialist. In the intervention group the number of actual and potential DRPs was significantly reduced to 1.5 per patient. Moreover, a significant reduction in adverse events (e.g. electrolyte disturbances and supratherapeutic INR's) was determined.

### *Comparison with other studies*

In the study of Hanlon *et al.*<sup>38</sup> in 57% of the prescriptions a potential DRP was determined compared to 24% in our control group. This can be explained by the fact that at the preoperative screening less attention could be given to the indication for and the effectiveness or adverse events of the medication, because of the lack of insight in the medical file of the patient from the GP. If more information had been available more potential DRPs would have been determined and more interventions would have been possible in the intervention group. In the study by Weiner *et al.* a pharmacy led medication safety program in orthopedic and spinal surgery patients led to a reduction of medication errors from 62% to 39% in the control and intervention group, respectively. The high number of medication errors in this study compared to our study can be explained by the fact that incorrect written or incomplete orders were also classified as error<sup>39</sup>. In the study of Buck *et al.* a suboptimal prescription was found in 20% of all patients on orthopedic wards. In 70% of cases these prescriptions were adjusted after intervention by a pharmacist<sup>40</sup>.

Medication reconciliation by pharmacists during the preadmission period has previously been shown to reduce the need for medication clarification postoperatively<sup>22;41</sup>. Our study results support the recent findings from a randomized controlled trial in Canada, which clearly demonstrated that a pharmacist's involvement in a preadmission clinic significantly reduced postoperative medication discrepancies related to home medications from (40.2% to 20.3% of patients in the control and intervention group, respectively<sup>42</sup>. In the study of Hick *et al.* the participation of a clinical pharmacist in the pre-operative setting of a surgical department led to an increased number of clinically relevant interventions<sup>22</sup>. In this study no specific details were given on the number of interventions in peri-operative drug management. The most important contribution to the process was considered transcribing discharge prescriptions.

Medication reconciliation is not the only tool to enhance medication safety. The clinical pharmacist can provide insight in the impact of continuing or stopping these medications. Moreover, it has been shown that as a result of incomplete drug use profiles, omissions to restart medication and lack of information, many modifications are necessary after discharge from the hospital in the medication use of the patient<sup>43</sup>. The studies by Walker and Kaparinar show that a pharmacy-led discharge service leads to significantly less medication discrepancies<sup>44;45</sup>. For drug management in orthopedic surgery the specialty 'orthopedic pharmacist' is recognized in England since a few years<sup>46</sup>.

The higher number of medications reported by patients in the intervention group is not unexpected since other studies have shown pharmacists often obtain more information than physicians and nurses about patients' medication use when they are admitted to hospital<sup>9;26</sup>. The study by Davis *et al.* showed an average number of chronic drugs used prior to hospitalization by patients aged 60 or more of 4.1, compared to 3.5 and 4.7 in the control and intervention group of our study, respectively<sup>47</sup>.

Our study shows that a comprehensive medication review contributes to the reduction in DRPs. The most important decrease of potential DRPs took place in the field of 'wrong drug' according to the updated Beers criteria<sup>32</sup>. This significant decrease in use of 'wrong drug' can be explained. Prior to the intervention the orthopedic surgeons in the study hospital were routinely using indomethacin to prevent heterotopic ossification (HO). During the transition from the control period to the intervention period, discussions were held with the prescribing surgeons in order to restrict the use of indomethacin to patients at high risk of HO because of the potential toxicity for this particular non-steroidal anti-inflammatory agent. Hence, it is possible a learning effect contributed to the results in this area. In addition, as part of the preoperative screening, the pharmacist made recommendations to the general practitioner to make therapy adjustments using the written feedback method. Although numbers are low in this study the results show a acceptance rate of 63%, which is considerably higher than the 17% found in another Dutch study<sup>48</sup>.

The analysis of medication use of the patients at hospital admittance shows that in only approximately 53% of the prescriptions the information from the GP and the community pharmacy is in accordance with patients' actual use. This is similar to prior outcomes<sup>26</sup>. This is partly caused by inadequate compliance of the patient and partly by inaccurate pharmacy and GP data. This inaccuracy is only partly caused by OTC-drug use from the patients. Additionally, 15% of the prescriptions is started in the period between the preoperative screening by the pharmacy and hospital admittance. This result shows the importance of the intake interview at day of admittance where attention is given to the medication use of the patient and a structured report is provided to the pharmacy.

The results show no significant decrease in the number of interactions after the intervention. This can be partially explained by the fact that both the intervention and control groups had routine computerized medication surveillance by the clinical pharmacist during their hospitalization. Moreover, the most frequent interaction that was determined was between NSAIDs and RAAS-inhibitors and/or diuretics, which is a relevant interaction since it can result in impaired hypertension control and/or renal failure<sup>49</sup>. However, this interaction is based mainly upon data on long-term concomitant use, which may not be relevant in short-term use<sup>33</sup>. The NSAIDs in our population were prescribed routinely for pain relief and prevention of HO. Only in patients with moderate or severe renal impairment a recommendation was made to the treating doctors to cease or not commence an NSAID. A further reduction of the number of potential DRPs could be achieved if NSAIDs would no longer be prescribed routinely in this population. The usefulness of routine use of NSAIDs for HO seems limited<sup>50</sup>.

Finally, the number of duplications was significantly reduced. During the control period it became apparent that many patients were receiving duplications of NSAIDs, acetaminophen and proton pump inhibitors, which were routinely prescribed to the patients for HO prevention, pain relief, and peptic ulcer prophylaxis, respectively. These duplications were not always recognized in the control group because medication surveillance did not always take place at the day of hospital admission but could occur after the operation.

The results of the intervention group show that in 24% of the patients an adjustment of the medication was necessary before the patient was admitted to hospital, e.g. ceasing of platelet inhibitors and anticoagulants. Furthermore ceasing or tapering SSRI's, stopping or tapering 'wrong drugs' according to the Beers criteria and starting of PPI because of prevention of NSAID-induced gastropathy are interventions for which the general practitioner of the patient or another specialist needs time to discuss with the patient. Therefore, timely involvement of the pharmacy in the process is essential. The preadmission surgery clinic seems to be the ideal time and place in the process for both patient and anesthesiologist in which the clinical pharmacy services start for this patient group. In the postoperative phase a drug was restarted in 17% of the patients that had been ceased peri-operatively and was omitted to restart at the time of discharge. This is comparable to other studies<sup>51</sup>. In the study of Hick *et al.* 10 omissions were determined in 50 patients. From the results of this study it was not clear whether this was in 10 different patients, although the results seem comparable to our study<sup>22</sup>. Another study showed elective hospitalization resulted in unintended cessation of warfarin in 11.4% of warfarin users<sup>51</sup>. Furthermore, a drug was permanently stopped by the pharmacist in 32% of the patients because there was no longer an indication. This is likely to result in a reduction in costs and possibly adverse events. Several studies have demonstrated the positive results of medication reconciliation<sup>44;45;52-57</sup>. A study in elderly medical and surgical patients showed that 44% had at least one unnecessary drug at hospital discharge<sup>52</sup>. In another study a drug could be stopped in 55% of discharged patients<sup>44</sup>.

### *Strengths and weaknesses*

The major strength of this study is that all possible aspects of pharmaceutical care for surgical patients have been implemented in the intervention group of this study. A complete follow-up of the patients during the whole process from preadmission clinic to discharge was achieved in both the intervention and control group. In contrast with prior studies not only medication reconciliation, or discharge services have been assessed. Compared to the study of Van den Bemt *et al.* peri-operative drug management advice to the anesthesiologist was not limited to anticoagulants<sup>28</sup>. Moreover, all possible DRPs have been determined based upon the widely used and accepted MAI-criteria<sup>30;31</sup>, except quality of directions provided to the patient, practicality of these directions and determination whether the cheapest alternative is used.

The study had insufficient power to show an impact on clinical endpoints or health care utilization such as postoperative complications, blood transfusions and unplanned readmissions. The results showed a significant decrease in adverse drug events and on the length of hospital stay. Whether this was as a result of the intervention at reducing the number of potential DRPs, or is a time trend independent of this study cannot be concluded from our data, although it has been shown in some earlier studies. Similarly the interventions are likely to affect clinical outcomes<sup>3-5;58</sup>, although the data is not consistent<sup>45</sup>. Further research in this area should be performed in order to specify the relation between potential DRPs, the MAI-score and clinical outcomes.

No one was blinded to the pharmacist intervention, which could have had an impact on the treating doctors to screen more carefully for DRPs themselves. This so called Hawthorne effect could have diluted the effect of the pharmacists' intervention<sup>59</sup>.

Finally, the cost-effectiveness of the activities performed by the pharmacist in this study was not determined. Given that this study suggests that the length of stay in hospital may be reduced because of the pharmacist intervention, future studies should address the economic impact of the intervention.

## Conclusion

The results of this study show that complete peri-operative drug management by clinical pharmacists not only reduces medication discrepancies, but also reduces actual and potential DRPs. The number of DRPs was reduced by approximately 50% from an average of 3.6 to 1.5 per patient in the control- and intervention group, respectively. Moreover, a significant reduction of adverse events was determined. Finally, discharge service based upon the pre- en peri-operative drug use of the patients rationalized drug use and prevented omission of drugs that were discontinued peri-operatively. In conclusion the clinical pharmacy service is an essential part of pharmaceutical care for orthopedic surgery patients and significantly enhances medication safety.

## Acknowledgement

This research had not been possible without the collaboration of all orthopedic surgeons, anesthesiologists, pharmacy technicians, nurses of the orthopedic and anesthesiology department, general practitioners, community pharmacists and employees of the medical archive. We thank Inge Redder, Rick Greupink and Lucia van der Veen for their assistance with the data processing. The study could be carried out due to unrestricted grants from health insurance company "De Friesland" and the Dutch Society of Hospital Pharmacists (NVZA).

## Reference List

1. Campion EW. A Death at Duke. *N Engl J Med* 2003; 348(12):1083-1084.
2. Leendertse AJ, Egberts AC, Stoker LJ, van den Bernt PM. Frequency of and risk factors for preventable medication-related hospital admissions in the Netherlands. *Arch Intern Med* 2008; 168(17):1890-1896.
3. Kaboli PJ, Hoth AB, McClimon BJ, Schnipper JL. Clinical pharmacists and inpatient medical care: a systematic review. *Arch Intern Med* 2006; 166(9):955-964.
4. Bond CA, Raehl CL, Franke T. Interrelationships among mortality rates, drug costs, total cost of care, and length of stay in United States hospitals: summary and recommendations for clinical pharmacy services and staffing. *Pharmacotherapy* 2001; 21(2):129-141.
5. Bond CA, Raehl CL. Clinical pharmacy services, pharmacy staffing, and adverse drug reactions in United States hospitals. *Pharmacotherapy* 2006; 26(6):735-747.

- 6** Zimmerman CR, Smolarek RT, Stevenson JG. Peer review and continuous quality improvement of pharmacists' clinical interventions. *Am J Health Syst Pharm* 1997; 54(15):1722-1727.
- 7** Gurwich EL. Comparison of medication histories acquired by pharmacists and physicians. *Am J Hosp Pharm* 1983; 40(9):1541-1542.
- 8** Jacobson J. Ensuring continuity of care and accuracy of patients' medication history on hospital admission. *Am J Health Syst Pharm* 2002; 59(11):1054-1055.
- 9** Nester TM, Hale LS. Effectiveness of a pharmacist-acquired medication history in promoting patient safety. *Am J Health Syst Pharm* 2002; 59(22):2221-2225.
- 10** Bobb A, Gleason K, Husch M, Feinglass J, Yarnold PR, Noskin GA. The Epidemiology of Prescribing Errors: The Potential Impact of Computerized Prescriber Order Entry. *Arch Intern Med* 2004; 164(7):785-792.
- 11** Dobrzanski S, Hammond I, Khan G, Holdsworth H. The nature of hospital prescribing errors. *Br J Clin Govern* 2002; 7:187-193.
- 12** Cornish PL, Knowles SR, Marchesano R, Tam V, Shadowitz S, Juurlink DN et al. Unintended medication discrepancies at the time of hospital admission. *Arch Intern Med* 2005; 165(4):424-429.
- 13** Nassaralla CL, Naessens JM, Hunt VL, Bhagra A, Chaudhry R, Hansen MA et al. Medication reconciliation in ambulatory care: attempts at improvement. *Qual Saf Health Care* 2009; 18(5):402-407.
- 14** Nassaralla CL, Naessens JM, Chaudhry R, Hansen MA, Scheitel SM. Implementation of a medication reconciliation process in an ambulatory internal medicine clinic. *Qual Saf Health Care* 2007; 16(2):90-94.
- 15** Pippins JR, Gandhi TK, Hamann C, Ndumele CD, Laborville SA, Diedrichsen EK et al. Classifying and predicting errors of inpatient medication reconciliation. *J Gen Intern Med* 2008; 23(9):1414-1422.
- 16** Gleason KM, McDaniel MR, Feinglass J, Baker DW, Lindquist L, Liss D et al. Results of the Medications At Transitions and Clinical Hand-offs (MATCH) Study: An Analysis of Medication Reconciliation Errors and Risk Factors at Hospital Admission. *J Gen Intern Med* 2010; 25(5):441-447.
- 17** Vira T, Colquhoun M, Etchells E. Reconcilable differences: correcting medication errors at hospital admission and discharge. *Qual Saf Health Care* 2006; 15(2):122-126.
- 18** Wong JD, Bajcar JM, Wong GG, Alibhai SM, Huh JH, Cesta A et al. Medication reconciliation at hospital discharge: evaluating discrepancies. *Ann Pharmacother* 2008; 42(10):1373-1379.
- 19** Duthie DJ, Montgomery JN, Spence AA, Nimmo WS. Concurrent drug therapy in patients undergoing surgery. *Anaesthesia* 1987; 42(3):305-306.
- 20** Burda SA, Hobson D, Pronovost PJ. What is the patient really taking? Discrepancies between surgery and anesthesiology preoperative medication histories. *Qual Saf Health Care* 2005; 14(6):414-416.
- 21** Institute for Healthcare Improvement. Protecting 5 million lives from harm. Getting started kit: prevent adverse drug events (medication reconciliation). How-to guide. [cited 2010 Mar. 15]; Available from: <http://www.ihl.org/ihl/Programs/Campaign/ADEsMedReconciliation.htm>
- 22** Hick HL, Deady PE, Wright DJ, Silcock J. The impact of the pharmacist on an elective general surgery pre-admission clinic. *Pharm World Sci* 2001; 23(2):65-69.
- 23** Jameson JP, VanNoord GR. Pharmacotherapy consultation on polypharmacy patients in ambulatory care. *Ann Pharmacother* 2001; 35(7-8):835-840.
- 24** Kripalani S, Jackson AT, Schnipper JL, Coleman EA. Promoting effective transitions of care at hospital discharge: a review of key issues for hospitalists. *J Hosp Med* 2007; 2(5):314-323.
- 25** Reeder TA, Mutnick A. Pharmacist- versus physician-obtained medication histories. *Am J Health Syst Pharm* 2008; 65(9):857-860.



- 26** Tam VC, Knowles SR, Cornish PL, Fine N, Marchesano R, Etchells EE. Frequency, type and clinical importance of medication history errors at admission to hospital: a systematic review. *CMAJ* 2005; 173(5):510-515.
- 27** Schnipper JL, Hamann C, Ndumele CD, Liang CL, Carty MG, Karson AS et al. Effect of an electronic medication reconciliation application and process redesign on potential adverse drug events: a cluster-randomized trial. *Arch Intern Med* 2009; 169(8):771-780.
- 28** van den Bernt PM, van den BS, van Nunen AK, Harbers JB, Lenderink AW. Medication reconciliation performed by pharmacy technicians at the time of preoperative screening. *Ann Pharmacother* 2009; 43(5):868-874.
- 29** Hepler CD, Strand LM. Opportunities and responsibilities in pharmaceutical care. *Am J Hosp Pharm* 1990; 47(3):533-543.
- 30** Fitzgerald LS, Hanlon JT, Shelton PS, Landsman PB, Schmader KE, Pulliam CC et al. Reliability of a modified medication appropriateness index in ambulatory older persons. *Ann Pharmacother* 1997; 31(5):543-548.
- 31** Samsa GP, Hanlon JT, Schmader KE, Weinberger M, Clipp EC, Uttech KM et al. A summated score for the medication appropriateness index: development and assessment of clinimetric properties including content validity. *J Clin Epidemiol* 1994; 47(8):891-896.
- 32** Fick DM, Cooper JW, Wade WE, Waller JL, Maclean JR, Beers MH. Updating the Beers criteria for potentially inappropriate medication use in older adults: results of a US consensus panel of experts. *Arch Intern Med* 2003; 163(22):2716-2724.
- 33** Roon van EN, Flikweert S, Le Comte M, Langendijk PN, Kwee-Zuiderwijk WJ, Smits P et al. Clinical relevance of drug-drug interactions : a structured assessment procedure. *Drug Saf* 2005; 28(12):1131-1139.
- 34** Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron* 1976; 16(1):31-41.
- 35** Owens WD, Felts JA, Spitznagel EL, Jr. ASA physical status classifications: a study of consistency of ratings. *Anesthesiology* 1978; 49(4):239-243.
- 36** Charlson ME, Pompei P, Ales KL, Mackenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987; 40(5):373-383.
- 37** World Health Organization. The WHO Collaborating Centre for Drug Statistics Methodology (accessed February 2006). <http://www.whocc.no/atcddd>
- 38** Hanlon JT, Weinberger M, Samsa GP, Schmader KE, Uttech KM, Lewis IK et al. A randomized, controlled trial of a clinical pharmacist intervention to improve inappropriate prescribing in elderly outpatients with polypharmacy. *Am J Med* 1996; 100(4):428-437.
- 39** Weiner BK, Venarske J, Yu M, Mathis K. Towards the reduction of medication errors in orthopedics and spinal surgery: outcomes using a pharmacist-led approach. *Spine* 2008; 33(1):104-107.
- 40** Buck TC, Brandstrup L, Brandslund I, Kampmann JP. The effects of introducing a clinical pharmacist on orthopaedic wards in Denmark. *Pharm World Sci* 2007; 29(1):12-18.
- 41** Gulka M, Walker J, Thiessen B, Gaucher M. Pharmacist-reviewed medication histories in a surgical preassessment clinic. *Can J Hosp Pharm* 1996; 49:29-31.
- 42** Kwan Y, Fernandes OA, Nagge JJ, Wong GG, Huh JH, Hurn DA et al. Pharmacist medication assessments in a surgical preadmission clinic. *Arch Intern Med* 2007; 167(10):1034-1040.
- 43** Cochrane RA, Mandal AR, Ledger-Scott M, Walker R. Changes in drug treatment after discharge from hospital in geriatric patients. *BMJ* 1992; 305(6855):694-696.

- 44** Karapinar-Carkit F, Borgsteede SD, Zoer J, Smit HJ, Egberts AC, van den Bernt PM. Effect of medication reconciliation with and without patient counseling on the number of pharmaceutical interventions among patients discharged from the hospital. *Ann Pharmacother* 2009; 43(6):1001-1010.
- 45** Walker PC, Bernstein SJ, Jones JN, Piersma J, Kim HW, Regal RE et al. Impact of a pharmacist-facilitated hospital discharge program: a quasi-experimental study. *Arch Intern Med* 2009; 169(21):2003-2010.
- 46** Graham R. A career as an orthopaedic pharmacist. *Hospital Pharmacist* 2005; 12:263-264.
- 47** Davis AW, Heavner JE. Polypharmacy, age, and scheduled surgery. *J Clin Anesth* 2002; 14(5):329-334.
- 48** Denneboom W, Dautzenberg MG, Grol R, De Smet PA. Treatment reviews of older people on polypharmacy in primary care: cluster controlled trial comparing two approaches. *Br J Gen Pract* 2007; 57(542):723-731.
- 49** Akinbamowo AO, Salzberg DJ, Weir MR. Renal consequences of prostaglandin inhibition in heart failure. *Heart Fail Clin* 2008; 4(4):505-510.
- 50** Fransen M, Anderson C, Douglas J, MacMahon S, Neal B, Norton R et al. Safety and efficacy of routine postoperative ibuprofen for pain and disability related to ectopic bone formation after hip replacement surgery (HIPAID): randomised controlled trial. *BMJ* 2006; 333(7567):519.
- 51** Bell CM, Bajcar J, Bierman AS, Li P, Mamdani MM, Urbach DR. Potentially unintended discontinuation of long-term medication use after elective surgical procedures. *Arch Intern Med* 2006; 166(22):2525-2531.
- 52** Hajjar ER, Hanlon JT, Sloane RJ, Lindblad CL, Pieper CF, Ruby CM et al. Unnecessary drug use in frail older people at hospital discharge. *J Am Geriatr Soc* 2005; 53(9):1518-1523.
- 53** Hugtenburg JG, Borgsteede SD, Beckeringh JJ. Medication review and patient counseling at discharge from the hospital by community pharmacists. *Pharm World Sci* 2009; 31(6):630-637.
- 54** Crotty M, Rowett D, Spurling L, Giles LC, Phillips PA. Does the addition of a pharmacist transition coordinator improve evidence-based medication management and health outcomes in older adults moving from the hospital to a long-term care facility? Results of a randomized, controlled trial. *Am J Geriatr Pharmacother* 2004; 2(4):257-264.
- 55** Scullin C, Scott MG, Hogg A, McElroy JC. An innovative approach to integrated medicines management. *J Eval Clin Pract* 2007; 13(5):781-788.
- 56** Al Rashed SA, Wright DJ, Roebuck N, Sunter W, Chrystyn H. The value of inpatient pharmaceutical counselling to elderly patients prior to discharge. *Br J Clin Pharmacol* 2002; 54(6):657-664.
- 57** Jack BW, Chetty VK, Anthony D, Greenwald JL, Sanchez GM, Johnson AE et al. A reengineered hospital discharge program to decrease rehospitalization: a randomized trial. *Ann Intern Med* 2009; 150(3):178-187.
- 58** Bond CA, Raehl CL. Clinical pharmacy services, pharmacy staffing, and hospital mortality rates. *Pharmacotherapy* 2007; 27(4):481-493.
- 59** McCarney R, Warner J, Iliffe S, van Haselen R, Griffin M, Fisher P. The Hawthorne Effect: a randomised, controlled trial. *BMC Med Res Methodol* 2007; 7:30.

